# CLAIMS

What is claimed is:

1. A method of operating a laser drilling system to manufacture gravure printing plates without etching or the use of hazardous chemicals, comprising:

activating a laser drilling system, including a picosecond laser, light valves, and a mechanism adapted to rotate a gravure cylinder blank;

operating the light valves, including setting the light valves to at least one of block and allow pulses of laser energy propagating from the laser drilling system that can ablate a linear pattern of cells along a substantially entire length of the gravure cylinder blank; and

drilling cells, including targeting the laser drilling system on the gravure cylinder blank, such that ablation of materials occurs as sub-beams propagate along an optical path to the target area and impinge upon the gravure cylinder blank, wherein specific cells within the target area of the gravure cylinder blank are drilled or not drilled according to settings of the light valves.

2. The method of claim 1, further comprising turning on purge gas before drilling cells, including opening a gas flow valve oriented to purge the gravure cylinder blank with a gas in order to remove debris generated during laser ablation from a target area.

3. The method of claim 1, further comprising deciding whether drilling is finished, including employing a control algorithm resident on a central computer to determine whether the gravure cylinder blank has been rotated around its axis a predetermined number of incremental steps, indicating that a substantially entire surface of gravure cylinder blank is populated with cells.

4. The method of claim 1, further comprising rotating the gravure cylinder blank while drilling is not finished, including rotating the gravure cylinder blank an incremental step of distance by the mechanism adapted to rotate the gravure cylinder blank, thereby aligning the cylinder to accomplish successive ablation of a next linear pattern of cells along the gravure cylinder blank.

5. The method of claim 1, further comprising closing a shutter interposed between a source of the pulses of laser energy and the gravure cylinder blank after drilling is finished, thereby stopping drilling of cells.

6. The method of claim 1, further comprising turning off purge gas after drilling is finished.

7. The method of claim 1, further comprising deactivating the laser drilling system after drilling is finished.

8. The method of claim 1, further comprising employing a polyimide film gravure cylinder blank.

9. The method of claim 1, further comprising employing a polyimide-filled gravure cylinder blank.

10. A single cell laser drilling system for use in manufacture of gravure printing plates without etching or the use of hazardous chemicals, comprising:

a picosecond laser emitting a beam 112 that propagates along an optical path;

a frequency doubling crystal in the optical path and operable to halve a wavelength of the beam;

a beam expander in the optical path and operable to increase a size of the beam a given number of times;

an objective lens in the optical path and operable to focus the beam onto a gravure cylinder blank at a given spot size, such that a hole conforming to the spotsize is ablated on the gravure cylinder blank.

11. The system of claim 10, wherein the beam expander is operable to increase the size of the beam three times.

12. The system of claim 10, wherein the picosecond laser and frequency doubling crystal provide sufficient pulse energy to ablate material in the gravure cylinder blank.

13. The system of claim 12, wherein the pulse energy is in a range from a few to a few hundred microjoules.

14. The system of claim 10, wherein pulse width is longer than a few picoseconds and less than 1000 picoseconds, bandwidth of the picosecond laser 110 is no more than 50% higher than a transform limit of a given pulse width, and pulse repetition rate is between 50-Hz to 1-MHz.

15. The system of claim 14, wherein the picosecond laser emits the beam with a wavelength of 1.053 micron, and the frequency doubling crystal converts a majority of the 1.053-micron beam to a 526-nm beam.

16. The system of claim 10, wherein the frequency doubling crystal halves the wavelength of the beam.

17. The system of claim 10, wherein the beam expander is a series of lenses that expands the beam from 1.5-mm in diameter to 4.5-mm in diameter.

18. The system of claim 10, wherein the objective lens focuses the beam on gravure cylinder blank to a spot size of 3 microns.

19. The system of claim 10, wherein the gravure cylinder blank is a hollow steel cylinder that is at least one of copper-plated and nickel-plated.

20. A short linear cell array laser drilling system for use in manufacture of gravure printing plates without etching or the use of hazardous chemicals, comprising:

a picosecond laser and frequency doubling crystal emitting a beam along an optical path;

a diffractive optical element in the optical path an operable to split the beam into a plurality of sub-beams that allow drilling of a linear series of cells on a gravure cylinder blank;

a scan lens in the optical path and operable to determine spot sizes of the sub-beams upon gravure cylinder blank 120;

a beam expander in the optical path and operable to increases a size of the beam by a given number of times, such that the beam is rendered big enough to cover several periods of the diffractive optical element, thereby allowing the diffractive optical element to function correctly as a beam splitter, and such that sub-beams are big enough to match a pupil size of the scan lens; and

light valves in the optical path and individually opened and closed by a control algorithm resident on a central computer to enable a pattern of cells to be cut on the gravure cylinder blank such that a printed image can be produced.

21. The system of claim 21, wherein the beam expander increases the size of the beam by six times.

22. The method of claim 20, further comprising an image transfer lens in the optical path and operable to re-image focal spots of sub-beams onto the gravure cylinder blank.

23. The system of claim 22, wherein the image transfer lens has an image magnification ratio of 1.

24. The system of claim 22, wherein the image transfer lens is composed of exactly two telecentric scan lenses placed back to back, with pupil planes of the two scan lenses coinciding in the center.

25. The system of claim 20, wherein the picosecond laser and frequency doubling crystal provide pulse energy in a range from a few hundred microjoules to a few tens millijoules, pulse width is longer than a few picoseconds and less than 1000 picoseconds, bandwidth of the picosecond laser is no more than 50% higher than

the transform limit of a given pulse width, and pulse repetition rate is between 50-Hz to 1-MHz.

26. The system of claim 20, wherein the picosecond laser emits the beam with a wavelength of 1.053 micron, and the frequency doubling crystal converts a majority of the 1.053-micron beam to a 526-nm beam.

27. The system of claim 20, wherein the beam expander is a pair of negative and positive lenses, the negative lens having a focal length of -24.9 mm and the positive lens having a focal length of 143.2 mm.

28. The system of claim 20, wherein the scan lens is an f-theta telecentric (scan) lens.

29. The system of claim 20, wherein the gravure cylinder blank is a hollow steel cylinder that is at least one of copper-plated and nickel-plated.

30. A long linear cell array laser drilling system for use in manufacture of gravure printing plates without etching or the use of hazardous chemicals, comprising:

a picosecond laser and frequency doubling crystal emitting a beam along an optical path;

a plurality of diffractive optical elements in the optical path, each operable to simultaneously divide an incident sub-beam into a linear series of dots that allow drilling of a plurality of sequential cells on a gravure cylinder blank;

a scan lens in the optical path and operable to determine dot sizes of the sub-beams upon gravure cylinder blank 120;

a beam expander in the optical path and operable to increase a size of the beam by a given number of times, such that the beam is rendered big enough to cover several periods of the diffractive optical element, thereby allowing the diffractive optical element to function correctly as a beam splitter, and such that sub-beams are big enough to match a pupil size of the scan lens;

a plurality of partial mirrors arranged in the optical path so that the beam is split into sub-beams that are each reflected to an associated diffractive optical element;

a plurality of light valves in the optical path and individually opened and closed by a control algorithm resident on a central computer to enable a linear pattern of cells to be cut on substantially an entire length of gravure cylinder blank at a single time; and

a rotating mechanism operable to sequentially rotate the gravure cylinder blank as successive linear cell patterns are drilled in a pattern according to a pre-defined control algorithm until a substantially entire surface of the gravure cylinder blank is populated with cells that form the printed image.

31. The system of claim 30, further comprising a plurality of image transfer lenses in the optical path and operable to re-image the dots of sub-beams onto the gravure cylinder blank.

32. The system of claim 31, wherein the plurality of image transfer lenses have an image magnification ratio of 1.

33. The system of claim 30, wherein the picosecond laser and frequency doubling crystal provide pulse energy in a range from a few millijoules to a few hundred millijoules, pulse width is longer than a few picoseconds and less than 1000 picoseconds, bandwidth of the picosecond laser is no more than 50% higher than the transform limit of a given pulse width, and pulse repetition rate is between 50-Hz to 1-MHz.

34. The system of claim 30, wherein the picosecond laser emits the beam with a wavelength of 1.053 micron, and the frequency doubling crystal converts a majority of the 1.053-micron beam to a 526-nm beam.

35. The system of claim 30, wherein the beam expander is a pair of negative and positive lenses, the negative lens having a focal length of -24.9 mm and the positive lens having a focal length of 143.2 mm.

36. The system of claim 30, wherein the partial mirrors are partially reflective with appropriate reflectivity to split beam strength evenly.

37. A gravure printing plate manufactured without etching or the use of hazardous chemicals, comprising:

a gravure cylinder blank bearing linear arrays of cells successively formed around its circumference by the operation of a laser drilling system successively ablating and rotating the gravure cylinder blank about its axis in incremental steps.

38. The printing plate of claim 37, wherein the blank has been successively ablated and rotated about its axis in incremental steps of 6 microns;

39. The printing plate of claim 37, wherein the gravure cylinder blank includes a quantity of copper cladding covering a steel core, which in turn surrounds a hollow center, and quantity of chromium plating covering the copper cladding.

40. The printing plate of claim 39, wherein each cell is formed by ablation of a portion of chromium plating.

41. The printing plate of claim 40, wherein the cells are 3 microns in diameter and 3 microns deep.

42. The printing plate of claim 37, wherein the gravure cylinder blank is a polyimide film gravure cylinder blank possessing chromium plating, copper cladding, a steel core, and a hollow center, wherein the blank is covered with a plurality of pre-formed cells and coated with a polyimide film of a regular thickness that covers the chromium plating and uniformly fills the pre-formed cells.

43. The printing plate of claim 42, wherein the pre-formed cells are 3 microns in diameter at a 6-micron pitch.

44. The printing plate of claim 43, wherein the linear arrays of cells are formed by ablating only the polyamide material in the pre-formed cells, such that chromium plating and copper cladding are not ablated.

45. The printing plate of claim 37, wherein the gravure cylinder blank is a polyimide-filled gravure cylinder blank possessing chromium plating, copper cladding, a steel core, and a hollow center, wherein the blank is covered with a plurality of pre-formed cells that are covered in turn with a low-ablation polyimide fill.

46. The printing plate of claim 45, wherein the pre-formed cells are 3 microns in diameter at a 6-micron pitch.

47. The printing plate of claim 46, wherein the linear arrays of cells are formed by ablating only the polyamide material in the pre-formed cells, such that chromium plating and copper cladding are not ablated.